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Paired-associate learning as a function of varying proportions of reinforcement.

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Introduction

The role of the frequency and pattern of reinforcements as a determinant of response strength has been investigated extensively in recent years (5,6,7,9). With the exception of an experiment reported by Goss and Rabaioli (4), however, these studies have been concerned with the acquisition and extinction of relatively simple classical and instrumental conditioned responses or choice reactions as functions of varying proportions of reinforcement.

Goss and Rabaioli investigated the acquisition of responses in a modified Thorndikian multiple-choice situation as a function of the randomly administered ratios of 100%, 75%, or 50% reinforcement for correct choices to each of eight multiple-choice units. After the learning criterion of 15 of 16 correct choices on two successive trials had been achieved, the Ss in each of the reinforcement conditions were divided into two groups. For 20 additional trials, correct choices for one of these groups were no longer reinforced while the proportions of reinforcements for correct choices administered to the other groups were cut to one-half of the acquisition proportions. Differences among the means of 22.3, 35.4 and 42.4 for trials and of 95.1, 154.1 and 178.1 for correct responses to the acqui-

sition criterion for the 100%, 75% and 50% conditions respectively were statistically significant and suggested that rate of acquisition was an inverse linear function of proportions of reinforcement from 50% to 100%. However, there were no differences among means of errors for the six groups to which the 20 trials under changed reinforcement proportions were administered. When correct responses were plotted as functions of changed reinforcement trials the six curves exhibited initial decrements from the acquisition criterion which were followed by upward trends. Therefore, while there were significant decreases in correct responses from criterion levels over the 20 trials as a whole the upward trends suggested that these decrements were not permanent for either halved or eliminated subgroups.

The present study was designed to supplement that of Goss and Rabaioli. Specifically, it investigated rate of acquisition of correct anticipations in the relatively complex paired-associate task as a function of varying proportions (100%, 75%, 50% and 25%) of reinforcement of such anticipations. Then, the study determined the effects on anticipatory responses of shifts in reinforcement proportions from the four acquisition proportions to no reinforcement of anticipations or to one-half of the acquisition proportions of reinforcement.

Method

Subjects.--One hundred and nine students, naive with respect to the experimental task, were randomly selected from classes in introductory psychology at the University of Massachusetts to serve as Ss. Because of E's errors, failure to understand instructions, and reported inability to concentrate on the task, data for eight of these Ss were discarded. Further, five additional Ss had to leave the experimental session before reaching the acquisition criterion. Thus, the entire learning task was completed by 96 Ss who had been randomly assigned to eight experimental groups of 12 Ss each. There were six males and six females in each of these groups.

Apparatus and stimulus materials.--Eight nonsense-syllable paired-acsociates were presented on a memory drum at a 3-sec. rate; that is, the stimulus member of each pair appeared alone for 3 seconds and was then presented either alone or together with the response syllable for an additional 3 seconds. The time interval between successive trials with the eight pair list was approximately 12 seconds in length.

The syllables used for stimuli are listed in the first column of Table 1 together with their respective paired-associates in the second column. The figures in

Table 1

Nonsense Syllables with Glaze Association Values*

Stimuli	Responses
FEC (47%)	JIR (53%)
HAX (47%)	MYD (53%)
JAL (53%)	TOF (53%)
KEM (47%)	WUS (47%)
NIW (47%)	XEL (53%)
RYG (53%)	KON (53%)
TOQ (53%)	BIH (47%)
VOD (47%)	CAZ (53%)

*Association values in the middle of the 0% to 100% range of such values had the advantage that, while learning was not so rapid that inter-condition differences were minimized, the task could be acquired by most Ss in less than an hour.

parentheses are Glaze (3) association values for each of the syllables.

These syllables were randomly selected from Underwood's (13,14) lists of syllables of low similarity as specified by frequency of repetition of letters, subject to restrictions of (a) no repetition of any consonants within either the eight stimulus or the eight response syllables, (b) no vowel appearing more than twice, (c) no letters in common for any stimulus-response pair, and (d) no common consonant-vowel or vowel-consonant combinations among the sixteen syllables. In order to prevent serial learning[1], these eight paired-associates were presented in four different randomly determined orders.

Procedure for acquisition trials.--The experimental design is outlined in Table 2. Subjects in all conditions were given the same standard instructions for paired-associate learning (Appendix A). The task consisted of anticipating the paired-associate during the 3-sec. interval when the stimulus syllable alone was presented. Anticipations were spelled rather than pronounced. Reinforcement was defined as the occurrence of both the

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1. Serial learning is the tendency to learn the response words by order of presentation instead of by responding to the stimuli. Randomization of orders also eliminates the possibility of Ss anticipating a stimulus before it is actually presented.

Table 2

Summary of Experimental Procedure

Group	N	Acquisition Reinforcement Proportions to Criterion*	Changed Reinforcement Proportions for 16 Trials
100-0	12	100	0
100-50	12	100	50
75-0	12	75	0
75-37.5	12	75	37.5
50-0	12	50	0
50-25	12	50	25
25-0	12	25	0
25-12.5	12	25	12.5

*To criterion of 15 of 16 correct anticipations over two successive trials.

stimulus and the paired response syllable during the remaining three seconds. Non-reinforcement was the non-appearance of the response syllable during the final three seconds. The acquisition criterion was 15 of 16 correct anticipations over two successive trials.

The administration of varying acquisition reinforcement proportions was as follows:

> 100% reinforcement.--The typical paired-associate procedure was followed; each of the eight stimulus-response pairs occurred on each trial. The four different random orders of the eight pairs were presented in a random sequence.
>
> 75% reinforcement.--Four patterns of reinforcement were randomly determined for each of the four orders of presentation of the eight units. Thus, there were 16 order-pattern combinations. The random assignment was subject to the restrictions that anticipations for each of the eight units were reinforced for 3 of the 4 patterns of each order and that 6 of 8 units were reinforced within each of the 16 order-pattern combinations. The combinations were presented in different random sequences within successive blocks of 16 trials.
>
> 50% reinforcement.--Four patterns of reinforcement were randomly determined for each of the four orders of presentation of the eight units to yield 16 order-pattern combinations. Anticipations for each unit were reinforced for two of the four patterns for each order and four of the eight units were reinforced within each of the 16 combinations. These combinations were also presented in different random sequences within successive blocks of 16 trials.
>
> 25% reinforcement.--With the exception that the reinforced units of each of the 16 order-pattern combinations of the 75% condition were not reinforced and the non-reinforced units were reinforced, the mode of presentation was the same as that followed for the 75% condition.

Procedure for changed reinforcement trials.--Without further instructions, and immediately following the second of the two criterion trials, Ss were given 16 trials under changed reinforcement conditions. Reinforcement for correct responses was completely eliminated for groups 100-0, 75-0, 50-0 and 25-0. The proportions of randomly predetermined reinforcements for each trial and for the correct response to each of the eight paired-associates was reduced from 100% to 50%, from 75% to 37.5%, from 50% to 25% and from 25% to 12.5% for the 100-50, 75-37.5, 50-25 and 25-12.5 groups respectively. The 100-50 group was given the first 16 of the random sequences of order-pattern combinations which had been determined for the 50% acquisition condition. Similarly, the first 16 of the random sequences for the 25% acquisition proportions were used for group 50-25. Reinforcements were administered randomly to the 75-37.5 group subject to restrictions that (a) anticipations for each paired-associate unit were reinforced three times within each of the two successive blocks of eight trials each and (b) three of the eight units were reinforced on each trial. For the 25-12.5 group only one anticipation was reinforced on each trial. Further, anticipations for each pair were reinforced only once within each of two blocks of eight trials each.

Results

Acquisition.--Table 3 presents means and standard deviations of trials, errors, and reinforced correct responses to criterion for the two groups of each reinforcement condition, separately and combined. Figure 1 represents means of both trials and errors as functions of proportions of reinforcement. Both curves exhibit slight negative acceleration or concaveness upward and, when extrapolated back from the 25% reinforcement proportion, are probably asymptotic with the Y-axis at 0 reinforcement.

Analysis of variance (2) involving the four reinforcement proportions times the two randomly assigned subgroups of each reinforcement proportion was used to test the hypothesis that there were no differences among means of trials, of errors, and of reinforced correct responses to criterion attributable to reinforcement proportions, random assignment to groups with each reinforcement proportion, and interaction of proportions and subgroups. The F's of 3.87 ($p = .05$) for means of trials and 5.36 ($p < .01$) for means of errors for the four reinforcement proportions permitted rejection of the hypothesis that there were no differences among trial and error means due to reinforcement proportions (Tables 4, 5). Since the random assignment and interaction F's for both trial and error measures were not significant

Table 3

Trials, Errors, and Reinforced Correct Responses to Criterion for the Two Subgroups of Each Reinforcement Proportion, Separately and Combined

Groups	N	Trials to Criterion		Errors to Criterion		Reinforced Correct Responses to Criterion	
		M	SD	M	SD	M	SD
100-0	12	20.8	9.9	82.2	36.0	83.8	46.1
100-50	12	25.0	8.8	107.9	43.2	97.1	29.6
75-0	12	23.1	6.0	103.5	28.1	58.3	18.5
75-37.5	12	25.8	7.6	115.5	35.8	66.1	21.9
50-0	12	27.3	6.4	130.8	35.8	38.3	9.2
50-25	12	24.4	8.8	112.4	45.5	39.2	16.8
25-0	12	32.7	9.7	145.8	46.2	24.8	10.3
25-12.5	12	29.2	8.3	137.6	46.2	20.7	6.6
100	24	22.9	9.6	95.0	41.8	90.5	39.3
75	24	24.5	6.9	109.5	32.7	62.2	20.6
50	24	25.8	7.9	121.6	41.9	38.7	13.5
25	24	30.9	9.2	141.8	46.4	22.8	8.9

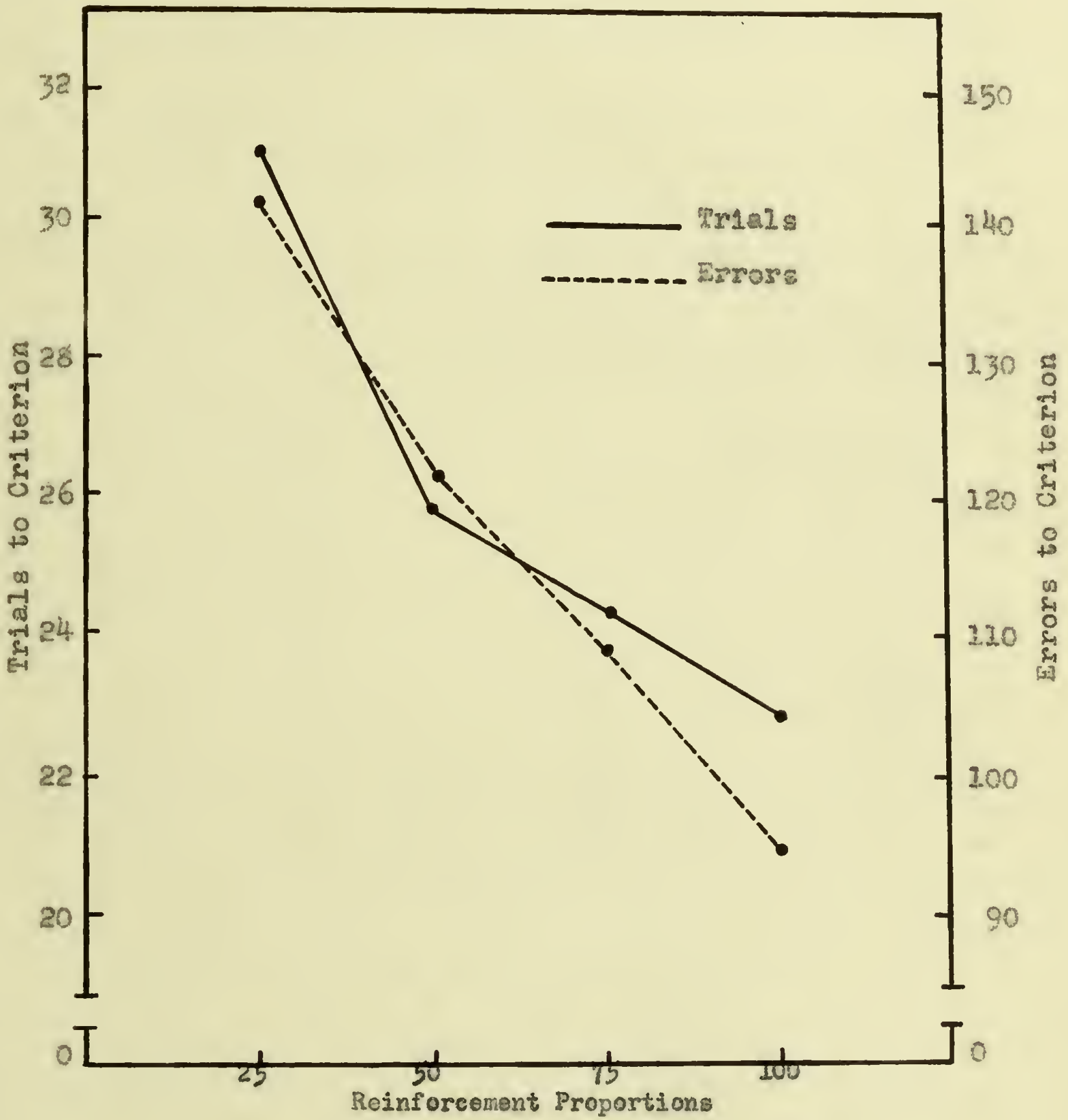

Figure 1

Means of Trials and Errors to Criterion as a Function of Acquisition Proportions of Reinforcement

Table 4

Analysis of Variance of Trials
to Acquisition Criterion

Source of variation	df	Sums of Squares	Mean Squares	F
Between reinforcement proportions	3	872.21	290.74	3.87*
Between 0 and halved groups (random assignment)	1	.67	.67	----
Interaction: proportions x assignment	3	274.75	91.58	1.22
Within groups	88	6608.33	75.09	
Total	95	7755.96		

*Significant at .05 level for 3, 88 df.

Table 5

Analysis of Variance of Errors
to Acquisition Criterion

Source of variation	df	Sums of Squares	Mean Squares	F
Between reinforcement proportions	3	28,186.45	9,395.48	5.36*
Between 0 and halved groups (random assignment)	1	189.84	189.84	.10
Interaction: proportions x assignment	3	7,079.62	2,349.87	1.34
Within groups	88	154,193.08	1,752.19	
Total	95			

*Significant at beyond .01 level for 3, 88 df.

at the 5% level it was concluded that neither of these sources of variation was related to acquisition performance.

The significance of the deviations from linearity of the two curves was tested by Lindquist's Case 3 procedure (Table 6). F's of 4.96 and 6.71 for the trial and error trends permitted rejection of the hypotheses of linearity at the 1% level of significance.

Finally, the significance of the downward trend from 25% to 100% reinforcement proportions was tested by comparisons of means of trials and errors to criterion for these extreme proportions. The use of mean squares of deviations within groups as estimates of error variances led to t's of 3.22 for trials and 11.92 for errors. Both values were significant at beyond the 1% level for 88 df. Thus, since over-all differences among means, deviations from linearity, and differences between extremes of reinforcement proportions were significant, it was concluded that whether measured by trials or measured by errors, rate of acquisition of the paired-associates was a negatively accelerated decay function of the proportion of reinforcements.

In describing the Ss employed it was noted that data for 5 Ss, specifically for 1, 1, 2 and 1 Ss in the 100%, 75%, 50% and 25% conditions respectively, were discarded

Table 6

Summary of Tests of Linearity by Lindquist's Case 3**

	Trials	Errors
SS_p	872.21	28,186.45
$(\Sigma xy)^2$	58,507,201.00	2,089,623,514.76
Σx^2	450,000.00	450,000.00
ms_w	74.82	1,755.03
k	4	4
F	4.96*	6.71*

*Significant at the .01 level for 3, 92 df.

**Lindquist's Case 3 involves the following F:

$$F = \frac{SS_p - \frac{(\Sigma xy)^2}{\Sigma x^2} \Big/ k-2}{ms_w}$$

SS_p is the sum of squares for the 100%, 75%, 50% and 25% proportions; Σxy is the total sum of products for an analysis of covariance with proportions as Xs and trials or errors as Ys; Σx^2 is the total sum of squares for xs; k is the number of proportions and ms_w is the mean square for within groups for a simple randomized design analysis of variance. The number of df for the F are k-2, and N-k where N is the total number of scores.

because these Ss had to leave the experimental situation before they had attained the acquisition criterion. Had these Ss continued to criterion the means of trials and errors for the four proportions would have been higher. Possible effects on the relationships between response measures and reinforcement proportions were checked by computing medians of trials and errors to criterion for each reinforcement proportion both for the 24 Ss in each condition for whom complete data were available and for the 24 plus the additional 1 or 2 Ss (Table 7). It will be noted that the data for the additional Ss merely increased the trial and error medians without altering the inverse relationship between the response measures and reinforcement proportions.

The F of 35.29 for differences among means of reinforced correct responses for reinforcement proportions was significant at beyond the 1% level (Table 8). The F's for between random assignment and interaction were not significant. A t comparison of the means of the 100% and 25% groups, using the mean squares of deviations within groups as the error estimate, yielded a value of 9.66 ($p<.01$). This difference along with the significant overall differences indicates that, as expected on the basis of the relationships for trials and errors, number of reinforced

Table 7

Medians of Trials and Errors to Criterion for 24 and with Additional Ss in the Reinforcement Conditions

Group	Medians of Trials to Criterion		Medians of Errors to Criterion	
	24 Ss	Additional Ss*	24 Ss	Additional Ss*
100	19.0	19.3**	91.0	92.0
75	23.7**	23.7**	106.8**	110.0
50	23.2**	25.0	120.0	120.7**
25	30.0	30.7**	131.0	136.3**

*Twenty-five, twenty-five, twenty-six and twenty-five Ss for 100, 75, 50 and 25% conditions respectively.

**Based on averages of adjacent scores when the N/2th score was indeterminate because of ties.

Table 8

Analysis of Variance of Reinforced Correct Responses to Criterion

Source of variation	df	Sums of Squares	Mean Squares	F
Between reinforcement proportions	3	62,546.54	20,848.85	35.29*
Between 0 and halved groups (random assignment	1	472.60	472.60	.80
Interaction: proportions x assignment	3	1,050.35	350.12	.59
Within groups	88	51,992.42	590.82	
Total	95			

*Significant at beyond .01 level for 3, 88 df.

correct trials to criterion is a direct function of reinforcement proportions. Put another way, under the 25% condition, far fewer reinforcements of correct responses are necessary for Ss to reach criterion than with larger proportions of reinforcements.

Changed reinforcement.--Table 9 summarizes the means and standard deviations of errors for the first four, the last twelve, and all sixteen trials under changed reinforcement proportions for the two degrees of change from acquisition reinforcement conditions and for the four acquisition reinforcement proportions.

Group 100-50 made the most errors during the first four trials. The 100-0 group had the highest means for the last 12 and all sixteen trials. However, since these means indicate an average of only one-half an error or less per trial, both groups were continuing to respond at the acquisition criterion level. All other groups averaged even fewer errors per trial. Thus, the changes from acquisition reinforcement proportions did not occasion a decrement in the number of correct anticipations over the 16 trials under these changed schedules of reinforcement.

Inspection of the data suggests that, as acquisition proportions of reinforcement decrease from 100% through 75% to 50% and 25%, there is a corresponding de-

Table 9

Means and Standard Deviations of Errors for the First 4, the Last 12, and all 16 Trials Under Changed Reinforcement Conditions

Group	First 4 Trials		Last 12 Trials		All 16 Trials	
	M	SD	M	SD	M	SD
100-0	1.3	2.3	6.8	12.61	8.2	10.7
100-50	3.4	1.8	1.7	2.6	5.1	4.0
75-0	2.4	1.7	2.3	5.4	4.8	5.9
75-37.5	1.5	2.2	2.7	2.5	4.2	4.3
50-0	1.2	1.4	.7	1.7	1.8	2.3
50-25	1.9	2.7	.9	1.7	2.8	4.0
25-0	.7	1.1	1.6	3.3	2.3	4.3
25-12.5	1.1	.6	.4	.8	1.5	.9
100	2.4	2.3	4.3	9.4	6.6	10.8
75	2.0	1.4	2.5	4.2	4.5	5.2
50	1.5	2.3	.8	1.7	2.3	3.3
25	.9	.9	1.0	2.4	2.5	4.4

crease in the number of errors under changed reinforcement conditions for the first four, last twelve, and all sixteen trials. Further, while not consistent between the first four and last 12 trials, for all 16 trials, with the exception of the 50% acquisition proportion groups, eliminating reinforcements apparently led to more errors than halving proportions.

Differences among the means for these three combinations or blocks of trials were analyzed by factorial analyses of variance involving acquisition proportions times the halved vs. eliminated degrees of change. As will be noted in Tables 10, 11, and 12, none of the Fs for acquisition proportions, halved vs. eliminated degrees of change, or interaction of acquisition proportions and degrees of change reached significance at the 5% level. Accordingly, it was concluded that the observed differences among means of errors for the eight groups, for the first 4, last 12, and all 16 trials, could have resulted from chance fluctuations. That is, neither acquisition proportions nor degree of change from acquisition proportions had statistically significant effects on the number of errors occurring under changed conditions.

Previous experimentation (8) had suggested that the greater the degree of change, particularly change to

Table 10

Analysis of Variance of Errors for the First Four Trials Under Changed Reinforcement Proportions

Source of variation	df	Sums of Squares	Mean Squares	F
Between reinforcement proportions	3	29.46	9.82	2.63
Between 0 and halved groups (random assignment)	1	8.17	8.17	2.20
Interaction: proportions x assignment	3	27.33	9.11	2.45
Within groups	88	327.67	3.72	
Total	95	392.63		

Table 11

Analysis of Variance of Errors for the Last 12 Trials Under Changed Reinforcement Proportions

Source of variation	df	Sums of Squares	Mean Squares	F
Between reinforcement proportions	3	184.68	61.56	2.07
Between 0 and halved groups (random assignment)	1	49.58	49.58	1.67
Interaction: proportions x assignment	3	119.90	39.97	1.34
Within groups	88	2,617.08	29.74	
Total	95	2,971.24		

Table 12

Analysis of Variance of Errors for All 16 Trials
Under Changed Reinforcement Proportions

Source of variation	df	Sums of Squares	Mean Squares	F
Between reinforcement proportions	3	342.45	114.15	2.60
Between 0 and halved groups (random assignment)	1	17.51	17.51	.40
Interaction: proportions x assignment	3	50.95	16.98	.39
Within groups	88	3,868.08	43.96	
Total	95	4,278.99		

non-reinforcement, the greater the number of errors. Therefore, means of errors for the three blocks of changed reinforcement trials for the 100-0 and 50-0 and the 100-0 and 25-0 groups were compared by t's. Using mean squares of deviations within groups to compute the error terms, differences for the first four in means of errors of 1.6, 4.4, and 5.4 were necessary for significance at the 5% level for the first 4, last 12, and all 16 trials respectively. While means of errors for the first 4 trials for the 50-0 and 25-0 groups did not differ significantly from the 100-0 mean of 1.3 errors, the means of errors for these groups were significantly lower than the corresponding means for the 100-0 group for the last 12, and all 16 trials. Thus, while overall differences among means of errors were not significant, there is some evidence that the greater shift in proportions for the 100-0 group led to more errors than the less marked changes for the 50-0 and 25-0 groups.

Discussion

Acquisition.--Analysis of the acquisition data suggested parallel, negatively accelerated decay functions relating acquisition proportions of reinforcement to trial and error measures. Goss and Rabaioli's data for the modified Thorndikian multiple-choice task suggested a linear relationship between response measures and proportions of reinforcement from the 50% to 100% points. The trial and error trends from 50% to 100% conditions of the present study were also nearly linear. (The 25% condition contributed most markedly to the overall negative acceleration.) Unfortunately, Goss and Rabaioli did not include a 25% condition which would have permitted comparison with the 25% to 50% change.

The slopes of the trends in Goss and Rabaioli's study, however, were much steeper than for the curves for the paired associate task. Specifically, the 50% reinforcement group of Goss and Rabaioli required approximately twice as many trials and errors to criterion than the 100% reinforcement group. In the present study, however, the 50% group required only 13% more trials and 28% more errors to criterion and the 25% group 34% more trials and 49% more errors than did the 100% group.

It is possible that differences between the

multiple-choice and paired-associate tasks with respect to stimuli and responses could account for the discrepancy in slopes. Or, buzzer reinforcement by E is probably not equivalent to the occurrence of the paired-associate stimuli for anticipatory responses. Therefore, type of reinforcement employed may determine the slopes of functions relating proportions of reinforcement to response measures.

Hull (1) has postulated that the strength of single stimulus-response relationships is a negatively accelerated growth function of the number of reinforcements. When generalized without adjustment for task differences this postulate implies inverse linear relationships between trial and error measures and proportions of reinforcement. Therefore, the present results were not consistent with an unmodified extension of Hull's theory.

Several factors which may account for this inconsistency can be identified. One of these is secondary reinforcement of responses on trials with no reinforcement by presentation of the paired syllables. Specifically, it might be hypothesized that for many Ss, particularly those in partial reinforcement conditions, the initial inability to master what seemed to be a simple task aroused anxiety and/or frustration drives (1).[2] Therefore, as correct

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2. During the course of the experiment Ss' remarks, when an incorrect response was given or when a "thought-to-be" correct response was not reinforced, suggested the presence of anxiety and frustration.

responses did begin to occur after inability to respond to a given stimulus on one to many preceding trials, this occurrence might have served as a reinforcement by leading to reduction of the anxiety and/or frustration drives.

Granting the possibility of anxiety and/or frustration drives and of reinforcement based on reduction of these drives, it might be postulated further that the lower the proportion of reinforcements the stronger the anxiety and/or frustration drives. Thus, when these drives were finally reduced by the occurrence of responses, it is possible that amount of reduction and thus of reinforcement was larger as the proportions of reinforcement decreased. If so, the advantage of the 100% group with respect to number of reinforcements would be, in part, offset not only by anxiety and/or frustration drive reduction but also by greater amounts of such reinforcement for the partially reinforced conditions.

The spread of effect (12) from reinforced to adjacent non-reinforced stimulus-response relationships is an additional factor. However, this phenomenon has not been demonstrated in paired-associate situations. At the present time, however, the ad hoc origin of these factors or explanations must be stressed. Whether their relevance can be demonstrated is a question which can be answered only by the

solution of a series of problems.

Changed reinforcement proportions.--Halving or eliminating the acquisition proportions of reinforcement of the eight groups did not lead to significant differences among overall immediate or eventual decrements from acquisition criterion levels over the 16 trials. Comparison of the means of errors for the 100-0 group with those for 50-0 and 25-0 conditions, however, resulted in significant *t*'s. Therefore, despite the significant overall difference this finding offered some support for the view that the greater the change from acquisition proportions, the greater the number of errors. Whether extinction trends would have been observed in the elimination of reinforcement groups had additional trials been given is possible, but as yet unverified. Thus, neither acquisition proportions of reinforcement nor degree of change from these proportions was related to errors during the 16 trials under changed reinforcement proportions.

While Goss and Rabaioli observed significant initial and overall decreases in correct responses from criterion levels these decreases were small and in part reversed by the final upward trends. Also, the differences among the means of correct responses (or errors) and in trends over the 20 trials were not significant. Therefore,

the changed reinforcement results of both studies are relatively consistent.

Goss and Rabaioli suggested a frustration-reduction source of reinforcement for elimination of reinforcement groups. That anxiety and/or frustration drive reduction served to reinforce responses in the present task was suggested above. It would seem possible that, at least for a number of trials under non-reinforcement conditions, the occurrence of anticipations continued to bring about reduction in these drives.

Summary

Ninety-six Ss, college students, learned a list of eight paired-associate units to an acquisition criterion of 15 of 16 correct responses for two successive trials. Paired nonsense syllables, or the stimulus member of each pair alone, were presented on a memory drum for 6 seconds, during the first 3 seconds of which the stimulus member appeared alone. Both syllables, or the same stimulus syllable alone, appeared during the remaining three seconds. Presentation of the paired response syllable during the remaining three seconds was defined as a reinforcement.

The Ss were randomly assigned to eight groups of 12 Ss each. Two of these groups received 100% reinforcement of paired-associate responses to criterion; two received 75% reinforcement for each paired-associate unit and on each trial; two received 50% reinforcement, and the remaining two received 25% reinforcement of responses for paired-associate units and on each trial.

After the Ss had reached criterion, reinforcement was halved for one of the 100% acquisition groups and eliminated for the other. The same procedure was followed for the two 75% acquisition proportion of reinforcement groups, the two 50% groups and the two 25% groups. All groups were given 16 trials under these changed conditions.

When means of trials and errors to criterion were plotted as functions of the proportions of reinforcement the curves were negatively accelerated decay functions, they showed that the 100% condition required the smallest number of trials and errors and that the 25% condition yielded the slowest learning.

Statistical analysis indicated that neither the proportions of reinforcement during acquisition nor halved vs.eliminated degrees of change were related to the number of errors made by the eight groups during the 16 trials under changed reinforcement proportions. Furthermore, all groups continued to respond at criterion levels. There was slight evidence, however, that when reinforcements were eliminated the decrements in errors for the 100% acquisition group was greater than for the 50% and 25% acquisition conditions.

These results were in general agreement with findings reported by Goss and Nabaioli, i.e., that the 100% condition led to more rapid acquisition of choice responses in a modified Thorndikian multiple-choice situation and that neither acquisition proportions nor degree of change was related to errors for 20 trials under halved vs. eliminated reinforcement conditions.

It was suggested that both during acquisition and during changed reinforcement trials there was some reinforce-

ment of responses even on trials when the second syllable did not appear. This reinforcement was ~~identified as~~ attributed to reduction of failure-induced anxiety or frustration drives. Specifically, it was hypothesized that these drives were aroused by Ss' initial inability to respond and, subsequently, that when Ss were learning to respond the occurrence of these responses then led to some drive-reduction.

References

1. Dollard, J., & Miller, N. E., Personality and psychotherapy. New York: McGraw-Hill, 1950.

2. Edwards, A. L., Experimental design in psychological research. New York: Rinehart, 1950.

3. Glaze, J. A., "The association value of nonsense syllables." Pedagogical seminary and J. genet. psychol., 1928, 35, 255-269.

4. Goss, A. E., & Rabaioli, E. J., "Response strength in a modified Thorndikian multiple-choice situation as a function of varying proportions of reinforcement." J. exp. psychol., 1952, 43, 106-114.

5. Grant, D. A., Hake, H. W., & Hornseth, J. P., "Acquisition and extinction of a verbal conditioned response with differing percentages of reinforcement." J. exp. psychol., 1951, 42, 1-5.

6. Grant, D. A., & Schipper, L. M., "The acquisition and extinction of conditioned eyelid responses as a function of the percentage of fixed-ratio random reinforcement." J. exp. psychol., 1952, 43, 313.

7. Grosslight, J. H., Hall, J. F., and Murnin, J., "Patterning effect in partial reinforcement." J. exp. psychol., 1953, 46, 103-106.

8. Jenkins, W. O., & Stanley, J. C., Jr., "Partial reinforcement: a review and critique." Psychol. bull., 1950, 47, 193-234.

9. Lewis, D. J., "Partial reinforcement in a gambling situation." J. exp. psychol., 1952, 43, 447-450.

10. Lindquist, E. F., Design and analysis of experiments in psychology and education. Boston: Houghton Mifflin Co., 1953.

11. Lindquist, E. F., "Goodness of fit of trend curves and significance of trend differences." Psychometrika, 1947, 12, 65-78.

12. McGeoch, J. A., & Irion, A. L., The psychology of human learning. New York: Longmans, Green and Co., 1952.

13. Underwood, B. J., "Studies of distributed practice: VII. Learning and retention of serial nonsense lists as a function of intralist similarity." J. exp. psychol., 1952, 44, 80-87.

14. Underwood, B. J., "Studies of distributed practice: VIII. Learning and retention of paired nonsense syllables as a function of intralist similarity." J. exp. psychol., 1953, 45, 133-142.

Appendix

A. Instructions Employed

This is an experiment in learning nonsense syllables and not a psychological test. We are interested in certain complex relationships of the learning process common to all people, and are not concerned with your personal reactions.

When the task begins this shutter will drop and you will see a three-letter nonsense syllable in a little window. After a few seconds the syllable will disappear and will appear again sometimes with another syllable. Together the two syllables represent a pair. You are to learn to associate the two so that when the first appears you can spell out the second before it is exposed. There will be several pairs which will not follow each other in any regular order. The two syllables of each pair, however, will always occur together.

An example would be the syllable XYZ which would first occur alone and then with a second syllable PQR. Your task will be to learn to spell out PQR as soon as you see XYZ and before PQR actually appears.

When you see the first syllable, if you think you know what the second syllable is, but are not sure, guess, because it will not hurt your score any more than to say nothing, and if you get it right, it will count as a success. If you spell the second syllable incorrectly, correct yourself by spelling it out loud as soon as it appears. Try to say each letter as distinctly as possible.

Please do not try to think ahead more than one step at a time, as to count, or to make up fanciful connections between the syllables to assist the learning. Don't try to use any special system in your learning; simply learn to spell out the second syllable as soon as the first is presented.

Remember, as the first syllable is presented spell out the other syllable before it is exposed. If you are wrong correct yourself by spelling the second syllable aloud as soon as it appears.

Do you have any questions?

B. Paired-associate Orders and Order-patterns of Reinforcement Proportions

100% Reinforcement

1	2	3	4	5	6	7	8
HAX	JAL	FEC	VOD	FEC	JAL	HAX	VOD
HAX MYD	JAL TOF	FEC JIR	VOD CAZ	FEC JIR	JAL TOF	HAX MYD	VOD CAZ
FEC	NIW	NIW	RYG	NIW	NIW	FEC	RYG
FEC JIR	NIW XEL	NIW XEL	RYG KON	NIW XEL	NIW XEL	FEC JIR	RYG KON
JAL	KEM	VOD	FEC	VOD	KEM	JAL	FEC
JAL TOF	KEM WUS	VOD CAZ	FEC JIR	VOD CAZ	KEM WUS	JAL TOF	FEC JIR
KEM	VOD	JAL	KEM	JAL	VOD	KEM	KEM
KEM WUS	VOD CAZ	JAL TOF	KEM WUS	JAL TOF	VOD CAZ	KEM WUS	KEM WUS
RYG	TOQ	TOQ	HAX	TOQ	TOQ	RYG	HAX
KYG KON	TOQ BIH	TOQ BIH	HAX MYD	TOQ BIH	TOQ BIH	RYG KON	HAX MYD
NIW	FEC	HAX	TOQ	HAX	FEC	NIW	TOQ
NIW XEL	FEC JIR	HAX MYD	TOQ BIH	HAX MYD	FEC JIR	NIW XEL	TOQ BIH
TOQ	RYG	RYG	NIW	RYG	RYG	TOQ	NIW
TOQ BIH	RYG KON	RYG KON	NIW XEL	RYG KON	RYG KON	TOQ BIH	NIW XEL
VOD	HAX	KEM	JAL	KEM	HAX	VOD	JAL
VOD CAZ	HAX MYD	KEM WUS	JAL TOF	KEM WUS	HAX MYD	VOD CAZ	JAL TOF

75% Reinforcement

1	2	3	4	5	6	7	8
HAX	FEC	HAX	VOD	VOD	VOD	JAL	JAL
HAX MYD	FEC JIR	HAX MYD	VOD CAZ	VOD	VOD CAZ	JAL	JAL TOF
FEC	NIW	FEC	RYG	RYG	RYG	NIW	NIW
FEC JIR	NIW	FEC JIR	RYG KON	RYG KON	RYG	NIW XEL	NIW XEL
JAL	VOD	JAL	FEC	FEC	FEC	KEM	KEM
JAL TOF	VOD CAZ	JAL TOF	FEC JIR	FEC	FEC JIR	KEM	KEM WUS
KEM	JAL	KEM	KEM	KEM	KEM	VOD	VOD
KEM	JAL TOF	KEM WUS	KEM WUS	KEM WUS	KEM	VOD CAZ	VOD CAZ
RYG	TOQ	RYG	HAX	HAX	HAX	TOQ	TOQ
RYG KON	TOQ BIH	RYG	HAX MYD	HAX MYD	HAXMYD	TOQ BIH	TOQ
NIW	HAX	NIW	TOQ	TOQ	TOQ	FEC	FEC
NIW	HAX MYD	NIW XEL	TOQ	TOQ BIH	TOQ BIH	FEC JIR	FEC
TOQ	RYG	TOQ	NIW	NIW	NIW	RYG	RYG
TOQ BIH	RYG	TOQ	NIW	NIW XEL	NIW XEL	RYG KON	RYG KON
VOD	KEM	VOD	JAL	JAL	JAL	HAX	HAX
VOD CAZ	KEM WUS	VOD CAZ	JAL TOF	JAL TOF	JAL TOF	HAX MYD	HAX MYD

75% Reinforcement (continued)

9	10	11	12	13	14	15	16
JAL	FEC	JAL	VOD	HAX	FEC	FEC	HAX
JAL TOF	FEC JIR	JAL TOF	VOD CAZ	HAX	FEC JIR	FEC	HAX MYD
NIW	NIW	NIW	RYG	FEC	NIW	NIW	FEC
NIW XEL	NIW XEL	NIW	RYG KON	FEC	NIW XEL	NIW XEL	FEC JIR
KEM	VOD	KEM	FEC	JAL	VOD	VOD	JAL
KEM WUS	VOD CAZ	KEM WUS	FEC JIR	JAL TOF	VOD CAZ	VOD	JAL
VOD	JAL	VOD	KEM	KEM	JAL	JAL	KEM
VOD	JAL	VOD CAZ	KEM WUS	KEM WUS	JAL TOF	JAL TOF	KEM WUS
TOQ	TOQ	TOQ	HAX	RYG	TOQ	TOQ	RYG
TOQ BIH	TOQ BIH	TOQ BIH	HAX	RYG KON	TOQ	TOQ BIH	RYG KON
FEC	HAX	FEC	TOQ	NIW	NAX	NAX	NIW
FEC JIR	HAX	FEC JIR	TOQ BIH	NIW XEL	HAX MYD	HAX MYD	NIW XEL
RYG	RYG	RYG	NIW	TOQ	RYG	RYG	TOQ
RYG	RYG KON	RYG KON	NIW XEL	TOQ BIH	RYG KON	RYG KON	TOQ BIH
HAX	KEM	HAX	JAL	VOD	KEM	KEM	VOD
HAX MYD	KEM WUS	HAX	JAL	VOD CAZ	KEM	KEM WUS	VOD

50% Reinforcement

1	2	3	4	5	6	7	8
HAX	FEC	HAX	VOD	VOD	VOD	JAL	JAL
HAX	FEC JIR	HAX	VOD	VOD CAZ	VOD CAZ	JAL TOF	JAL
FEC	NIW	FEC	RYG	RYG	RYG	NIW	NIW
FEC JIR	NIW	FEC JIR	RYG	RYG KON	RYG KON	NIW	NIW
JAL	VOD	JAL	FEC	FEC	FEC	KEM	KEM
JAL	VOD	JAL	FEC JIR	FEC JIR	FEC	KEM	KEM
KEM	JAL	KEM	KEM	KEM	KEM	VOD	VOD
KEM WUS	JAL TOF	KEM WUS	KEM WUS	KEM	KEM	VOD CAZ	VOD CAZ
RYG	TOQ	RYG	HAX	HAX	HAX	TOQ	TOQ
RYG KON	TOQ	RYG KON	HAX	HAX	HAX MYD	TOQ BIH	TOQ BIH
NIW	HAX	NIW	TOQ	TOQ	TOQ	FEC	FEC
NIW	HAX	NIW XEL	TOQ BIH	TOQ	TOQ	FEC	FEC JIR
TOQ	RYG	TOQ	NIW	NIW	NIW	RYG	RYG
TOQ BIH	RYG KON	TOQ	NIW XEL	NIW XEL	NIW	RYG	RYG KON
VOD	KEM	VOD	JAL	JAL	JAL	HAX	HAX
VOD	KEM WUS	VOD	JAL	JAL	JAL TOF	HAX MYD	HAX

50% Reinforcement (continued)

9	10	11	12	13	14	15	16
JAL	FEC	JAL	VOD	HAX	FEC	FEC	HAX
JAL TOF	FEC	JAL	VOD	HAX MYD	FEC JIR	FEC	HAX MYD
NIW	NIW	NIW	RYG	FEC	NIW	NIW	FEC
NIW XEL	NIW XEL	NIW XEL	RYG	FEC	NIW	NIW XEL	FEC
KEM	VOD	KEM	FEC	JAL	VOD	VOD	JAL
KEM WUS	VOD CAZ	KEM WUS	FEC	JAL TOF	VOD CAZ	VOD	JAL TOF
VOD	JAL	VOD	KEM	KEM	JAL	JAL	KEM
VOD	JAL	VOD	KEM WUS	KEM	JAL TOF	JAL	KEM
TOQ	TOQ	TOQ	HAX	RYG	TOQ	TOQ	RYG
TOQ	TOQ BIH	TOQ	HAX MYD	RYG	TOQ BIH	TOQ	RYG
FEC	HAX	FEC	TOQ	NIW	HAX	HAX	NIW
FEC	HAX MYD	FEC JIR	TOQ BIH	NIW XEL	HAX	HAX MYD	NIW
RYG	RYG	RYG	NIW	TOQ	RYG	RYG	TOQ
RYG	RYG	RYG KON	NIW	TOQ	RYG	RYG KON	TOQ BIH
HAX	KEM	HAX	JAL	VOD	KEM	KEM	VOD
HAX MYD	KEM	HAX	JAL TOF	VOD CAZ	KEM	KEM WUS	VOD CAZ

37.5% Reinforcement

1	2	3	4	5	6	7	8
HAX	FEC	HAX	VOD	VOD	VOD	JAL	JAL
HAX MYD	FEC JIR	HAX MYD	VOD	VOD CAZ	VOD CAZ	JAL	JAL
FEC	NIW	FEC	RYG	RYG	RYG	NIW	NIW
FEC	NIW XEL	FEC	RYG	RYG KON	RYG KON	NIW XEL	NIW XEL
JAL	VOD	JAL	FEC	FEC	FEC	KEM	KEM
JAL TOF	VOD CAZ	JAL TOF	FEC	FEC	FEC	KEM	KEM WUS
KEM	JAL	KEM	KEM	KEM	KEM	VOD	VOD
KEM	JAL	KEM	KEM	KEM	KEM	VOD CAZ	VOD
RYG	TOQ	RYG	HAX	HAX	HAX	TOQ	TOQ
RYG	TOQ	RYG	HAX MYD	HAX MYD	HAX	TOQ	TOQ
NIW	HAX	NIW	TOQ	TOQ	TOQ	FEC	FEC
NIW	HAX	NIW	TOQ BIH	TOQ	TOQ	FEC JIR	FEC JIR
TOQ	RYG	TOQ	NIW	NIW	NIW	RYG	RYG
TOQ	RYG	TOQ BIH	NIW	NIW	NIW	RYG	RYG
VOD	KEM	VOD	JAL	JAL	JAL	HAX	HAX
VOD CAZ	KEM	VOD	JAL TOF	JAL	JAL TOF	HAX	HAX

37.5% Reinforcement (continued)

9	10	11	12	13	14	15	16
JAL	FEC	JAL	VOD	HAX	FEC	FEC	HAX
JAL TOF	FEC JIR	JAL	VOD	HAX	FEC JIR	FEC	HAX MYD
NIW	NIW	NIW	RYG	FFC	NIW	NIW	FEC
NIW	NIW XEL	NIW XEL	RYG KON	FEC JIR	NIW XEL	NIW	FEC
KEM	VOD	KEM	FEC	JAL	VOD	VOD	JAL
KEM WUS	VOD	KEM	FEC	JAL	VOD	VOD	JAL
VOD	JAL	VOD	KEM	KEM	JAL	JAL	KEM
VOD	JAL	VOD CAZ	KEM WUS	KEM WUS	JAL	JAL TOF	KEM
TOQ	TOQ	TOQ	HAX	RYG	TOQ	TOQ	RYG
TOQ	TOQ	TOQ	HAX MYD	RYG	TOQ BIH	TOQ BIH	RYG KON
FEC	HAX	FEC	TOQ	NIW	HAX	HAX	NIW
FEC	HAX	FEC	TOQ	NIW	HAX	HAX	NIW
RYG	RYG	RYG	NIW	TOQ	RYG	RYG	TOQ
RYG KON	RYG	RYG KON	NIW	TOQ BIH	RYG	RYG	TOQ BIH
HAX	KEM	HAX	JAL	VOD	KEM	KEM	VOD
HAX	KEM WUS	HAX	JAL	VOD	KEM	KEM WUS	VOD

25% Reinforcement

1	2	3	4	5	6	7	8
HAX	FEC	HAX	VOD	VOD	VOD	JAL	JAL
HAX	FEC	HAX	VOD	VOD CAZ	VOD	JAL TOF	JAL
FEC	NIW	FEC	RYG	RYG	RYG	NIW	NIW
FEC	NIW XEL	FEC	RYG	RYG	RYG KON	NIW	NIW
JAL	VOD	JAL	FEC	FEC	FEC	KEM	KEM
JAL	VOD	JAL	FEC	FEC JIR	FEC	KEM WUS	KEM
KEM	JAL	KEM	KEM	KEM	KEM	VOD	VOD
KEM WUS	JAL	KEM	KEM	KEM	KEM WUS	VOD	VOD
RYG	TOQ	RYG	HAX	HAX	HAX	TOQ	TOQ
RYG	TOQ	RYG KON	HAX	HAX	HAX	TOQ	TOQ BIH
NIW	HAX	NIW	TOQ	TOQ	TOQ	FEC	FEC
NIW XEL	HAX	NIW	TOQ BIH	TOQ	TOQ	FEC	FEC JIR
TOQ	RYG	TOQ	NIW	NIW	NIW	RYG	RYG
TOQ	RYG KON	TOQ BIH	NIW XEL	NIW	NIW	RYG	RYG
VOD	KEM	VOD	JAL	JAL	JAL	HAX	HAX
VOD	KEM	VOD	JAL	JAL	JAL	HAX	HAX

25% Reinforcement (continued)

9	10	11	12	13	14	15	16
JAL	FEC	JAL	VOD	HAX	FEC	FEC	HAX
JAL	FEC	JAL	VOD	HAX MYD	FEC	FEC JIR	HAX
NIW	NIW	NIW	RYG	FEC	NIW	NIW	FEC
NIW	NIW	NIW XFL	RYG	FEC JIR	NIW	NIW	FEC
KEM	VOD	KEM	FEC	JAL	VOD	VOD	JAL
KEM	VOD	KEM	FEC	JAL	VOD	VOD CAZ	JAL TOF
VOD	JAL	VOD	KEM	KEM	JAL	JAL	KEM
VOD CAZ	JAL TOF	VOD	KEM	KEM	JAL	JAL	KEM
TOQ	TOQ	TOQ	HAX	RYG	TOQ	TOQ	RYG
TOQ	TOQ	TOQ	HAX MYD	RYG	TOQ BIH	TOQ	RYG
FEC	HAX	FEC	TOQ	NIW	HAX	HAX	NIW
FEC	HAX MYD	FEC	TOQ	NIW	HAX	HAX	NIW
RYG	RYG	RYG	NIW	TOQ	RYG	RYG	TOQ
RYG KON	RYG	RYG	NIW	TOQ	RYG	RYG	TOQ
HAX	KEM	HAX	JAL	VOD	KEM	KEM	VOD
HAX	KEM	HAX MYD	JAL TOF	VOD	KEM WUS	KEM	VOD CAZ

12.5% Reinforcement

1	2	3	4	5	6	7	8
HAX	FEC	HAX	VOD	VOD	VOD	JAL	JAL
HAX	FEC	HAX MYD	VOD	VOD	VOD	JAL	JAL
FEC	NIW	FEC	RYG	RYG	RYG	NIW	NIW
FEC	NIW	FEC	RYG KON	RYG	RYG	NIW	NIW
JAL	VOD	JAL	FEC	FEC	FEC	KEM	KEM
JAL	VOD	JAL	FEC	FEC	FEC JIR	KEM	KEM
KEM	JAL	KEM	KEM	KEM	KEM	VOD	VOD
KEM WUS	JAL	KEM	KEM	KEM	KEM	VOD	VOD
RYG	TOQ	RYG	HAX	HAX	HAX	TOQ	TOQ
RYG	TOQ	RYG	HAX	HAX	HAX	TOQ	TOQ
NIW	HAX	NIW	TOQ	TOQ	TOQ	FEC	FEC
NIW	HAX MYD	NIW	TOQ	TOQ	TOQ	FEC JIR	FEC
TOQ	RYG	TOQ	NIW	NIW	NIW	RYG	RYG
TOQ	RYG	TOQ	NIW	NIW	NIW	RYG	RYG KON
VOD	KEM	VOD	JAL	JAL	JAL	HAX	HAX
VOD	KEM	VOD	JAL	JAL TOF	JAL	HAX	HAX

12.5% Reinforcement (continued)

9	10	11	12	13	14	15	16
JAL	FEC	JAL	VOD	HAX	FEC	FEC	HAX
JAL	FEC	JAL TOF	VOD	HAX	FEC	FEC	HAX
NIW	NIW	NIW	RYG	FEC	NIW	NIW	FEC
NIW	NIW	NIW	RYG	FEC	NIW	NIW	FEC
KEM	VOD	KEM	FEC	JAL	VOD	VOD	JAL
KEM	VOD	KEM	FEC	JAL	VOD	VOD CAZ	JAL
VOD	JAL	VOD	KEM	KEM	JAL	JAL	KEM
VOD CAZ	JAL	VOD	KEM	KEM	JAL	JAL	KEM
TOQ	TOQ	TOQ	HAX	RYG	TOQ	TOQ	RYG
TOQ	TOQ BIH	TOQ	HAX	RYG	TOQ	TOQ	RYG
FEC	HAX	FEC	TOQ	NIW	HAX	HAX	NIW
FEC	HAX	FEC	TOQ	NIW XEL	HAX	HAX	NIW
RYG	RYG	RYG	NIW	TOQ	RYG	RYG	TOQ
RYG	RYG	RYG	NIW XEL	TOQ	RYG	RYG	TOQ BIH
HAX	KEM	HAX	JAL	VOD	KEM	KEM	VOD
HAX	KEM	HAX	JAL	VOD	KEM WUS	KEM	VOD

0% Reinforcement

1	2	3	4	5	6	7	8
JAL	FEC	JAL	VOD	HAX	FEC	FEC	HAX
JAL	FEC	JAL	VOD	HAX	FEC	FEC	HAX
NIW	NIW	NIW	RYG	FEC	NIW	NIW	FEC
NIW	NIW	NIW	RYG	FEC	NIW	NIW	FEC
KEM	VOD	KEM	FEC	JAL	VOD	VOD	JAL
KEM	VOD	KEM	FEC	JAL	VOD	VOD	JAL
VOD	JAL	VOD	KEM	KEM	JAL	JAL	KEM
VOD	JAL	VOD	KEM	KEM	JAL	JAL	KEM
TOQ	TOQ	TOQ	HAX	RYG	TOQ	TOQ	RYG
TOQ	TOQ	TOQ	HAX	RYG	TOQ	TOQ	RYG
FEC	HAX	FEC	TOQ	NIW	HAX	HAX	NIW
FEC	HAX	FEC	TOQ	NIW	HAX	HAX	NIW
RYG	RYG	RYG	NIW	TOQ	RYG	RYG	TOQ
RYG	RYG	RYG	NIW	TOQ	RYG	RYG	TOQ
HAX	KEM	HAX	JAL	VOD	KEM	KEM	VOD
HAX	KEM	HAX	JAL	VOD	KEM	KEM	VOD

C. Data for Individual Ss Under Acquisition and Changed Reinforcement Conditions

Table C1

Trials to Acquisition Criterion for Individual Ss

Subject	100-0	100-50	75-0	75-37.5	50-0	50-25	25-0	25-12.5
1	33	24	29	16	23	10	40	40
2	15	13	23	29	23	19	33	30
3	19	43	15	22	30	22	40	36
4	18	23	15	26	36	37	22	32
5	16	19	22	20	38	20	25	25
6	13	31	24	22	24	23	27	42
7	12	26	37	12	17	19	18	23
8	13	39	19	26	31	22	51	22
9	15	16	22	33	26	29	26	20
10	17	29	20	39	34	17	47	15
11	34	17	24	31	18	32	33	39
12	44	20	28	34	27	43	30	26

Table C2

Errors to Acquisition Criterion for Individual Ss

Subject	100-0	100-50	75-0	75-37.5	50-0	50-25	25-0	25-12.5
1	114	106	134	65	120	43	169	199
2	57	56	114	153	105	93	131	122
3	94	209	67	74	158	97	175	168
4	90	94	75	127	167	197	106	131
5	61	92	79	95	174	122	92	116
6	55	132	122	102	101	101	156	236
7	41	96	167	58	81	60	69	116
8	47	177	82	129	154	105	183	104
9	71	76	95	142	140	120	121	96
10	59	112	97	173	173	77	253	63
11	141	73	86	114	61	136	148	176
12	156	72	124	154	136	198	147	126

Table C3

Reinforced Correct Responses to Acquisition Criterion for Individual Ss

Subject	100-0	100-50	75-0	75-37.5	50-0	50-25	25-0	25-12.5
1	150	86	72	43	26	18	34	30
2	63	48	51	58	36	14	29	25
3	58	135	36	74	40	38	30	24
4	54	94	26	58	53	49	13	29
5	67	60	69	48	55	16	24	19
6	49	116	49	54	37	45	12	23
7	55	112	94	28	24	44	16	14
8	57	135	49	58	42	34	51	13
9	49	52	61	90	32	55	18	13
10	77	120	44	101	46	32	27	11
11	131	119	76	94	36	54	25	29
12	196	88	73	87	32	72	19	18

Table C4

Errors Under Changed Reinforcement Proportions for Individual Ss

Subject	100-0	100-50	75-0	75-37.5	50-0	50-25	25-0	25-12.5
1	0	3	3	4	4	1	2	2
2	0	5	1	0	0	1	1	0
3	1	8	0	1	4	0	2	2
4	2	5	4	4	0	6	1	0
5	8	4	8	2	2	15	0	2
6	2	3	3	2	0	1	16	1
7	2	4	23	1	4	1	1	1
8	0	3	3	6	7	3	0	1
9	40	1	3	4	1	4	0	3
10	1	17	4	17	0	1	3	2
11	41	3	0	3	0	0	0	3
12	1	5	5	6	0	1	1	1

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